R10272846

24590-PTF-N1D-FEP-P0008
Rev. 0

PLANT ITEM MATERIAL SELECTION DATA SHEET

FEP-RBLR-00001A/B (PTF)
Waste Feed Evaporator Reboilers

- Design Temperature (°F)(max/min): 311/49
- Design Pressure (psig) (max/min) 50/FV
- Location: incell

ISSUED BY RPP-WTP PDC 3/29/04 INIT DATE

Contents of this document are Dangerous Waste Permit affecting

Operating conditions are as stated on sheet 5

Operating Modes Considered:

- pH 13; halide concentrations similar to FEP-SEP-00001-A/B; operating temperature 140°F

Materials Considered:

Material (UNS No.)	Relative Cost	Acceptable Material	Unacceptable Material
Carbon Steel	0.23		X
304L (S30403)	1.00	X	
316L (S31603)	1.18	X	
6% Mo (N08367/N08926)	7.64	X	
Alloy 22 (N06022)	11.4	X	
Ti-2 (R50400)	10.1		X

Recommended Material: Shell: 304 (max 0.030%C; dual certified)
Tubes: G-30 or equivalent

Recommended Corrosion Allowance: none on shell side
0.04 inch on tube side

Process & Operations Limitations:

- Develop flushing/rinsing procedure for acid or water

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This bound document contains a total of 5 sheets.

REV	DATE	REASON FOR REVISION	PREPARER	CHECKER	APPROVER
0	3/19/04	Issued for Permitting Use			

Corrosion Considerations:

a General Corrosion
Hamner's data (1981) lists a corrosion rate for 304 (and 304L) in NaOH of less than 20 mpy (500 μm/y) at 77°F and over 20 mpy at 122°F He shows 316 (and 316L) has a rate of less than 2 mpy up to 122°F and 50% NaOH. Sedriks (1996) states that the 300 series stainless steels are acceptable in up to 50% NaOH at temperatures up to about 122°F or slightly above. Work with simulated-radwaste evaporators, six months at 140°F, showed 304L was slightly more resistant to corrosion (<0.2 mpy) than was 316L (<0.6 mpy). Ni 200, pure nickel, was much less resistant (≈7 mpy) probably due to the complexants.

Davis (1994) states the corrosion rate for 304L in pure NaOH will be less than about 0 1 mpy up to about 212°F though Sedriks states the data above 122°F are incorrect Danielson & Pitman, (2000) based on short-term studies, suggest a corrosion rate of about 0.5 mpy for 316L in simulated waste at boiling.

Ohl & Carlos (1994) found in their review of the 242-A Evaporator with waste similar to that expected in LAW that the corrosion of 304L was less than the accepted variability of the plate thickness after two years of operation at 140°F. Because of uncertainties of the starting wall thickness, a review of the raw data was inconclusive. 304L appears have corroded at an average rate of about 10 mpy though it may have been higher or lower

Uhlig (1948) has shown that pure nickel is more resistant to corrosion by NaOH than stainless steel However, the presence of complexing agents may reverse the trend. Agarwal (2000) states that the higher nickel alloys are highly corrosion resistant though specific mention of alkaline media is not made. The general literature mainly discusses cracking problems (see below) rather than uniform corrosion.

Zapp (1998) notes that the evaporator vessels at Savannah River Site are made of 304L and have suffered no failures in over 30 years of operation. Savannah River uses G-3 and G-30 alloys for the evaporator tubes.

Conclusion. For the shell, it appears that 304L can be used at temperatures up to the stated operating temperature.

Based on testing, 304L would be satisfactory for the tubes. However, if it is assumed the temperature can approach low pressure steam temperatures, then, based on Savannah River data, a higher alloy is recommended for the tubes. Some of the data described above suggest that a high chromium and perhaps molybdenum content will be needed. G-30 alloy, based on the current Savannah River experience, can be selected.

b Pitting Corrosion
Chloride is notorious for causing pitting in acid and neutral solutions. It is found that in alkaline solutions, pH>12, chlorides are likely to promote pitting only in tight crevices. Koch (1995) is of the opinion that fluoride will have little effect. Jenkins (1998) has stated that localized corrosion can occur under the deposits on tubes, probably due to the chlorides.

Revie (2000) and Uhlig (1948) note that nitrate inhibits chloride corrosion. Therefore the high nitrate concentrations in the LAW are expected to be beneficial.

The apparent lack of pitting in the 242-A Evaporator suggests 304L is acceptable at the design conditions. Zapp (1998) confirms the behavior of 304L in the shell. Use of austenitic alloys is not recommended for the tubes.

The higher nickel and molybdenum alloys, such as AL6XN, C-22, G-30, are expected to be more pitting resistant than the austenitic alloys. Because high purity nickel, Ni 200, did not fare well in tests in the presence of complexants, but the chromium content of the alloys may mitigate that effect. Jenkins (1998) reports that G3 and G30 evaporator tubes have used successfully at Savannah River Site for over 10 years and they expect at least 20 years service; 304L had failed after about 10 years. The shell of the evaporator has performed successfully for approximately 30 years.

Conclusion: Localized corrosion, such as pitting, is common but probably can be mitigated by alloys with higher nickel and molybdenum contents even under heat transfer conditions or where deposits can form. Based on Savannah River data, the shell is expected to be free of significant corrosion and can be 304L.

c End Grain Corrosion
End grain corrosion only occurs in metal with exposed end grains and in highly oxidizing acid conditions

Conclusion: Not applicable to this system

d Stress Corrosion Cracking
The exact amount of chloride required to stress corrosion crack stainless steel is unknown. In part this is because the amount varies with temperature, metal sensitization, and the environment. But it is also unknown because chloride tends to concentrate under heat transfer conditions, by evaporation, and electrochemically during a corrosion process. Hence, even as little as 10 ppm can lead to cracking under some conditions. The use of "L" grade stainless reduces the opportunity for sensitization. From the above references, it is also observed that alkaline conditions reduce the probability of the initiation of stress corrosion cracking to essentially zero. However, should a pit or crevice, including a deposit, be present where the environment can become acid, then the alkaline environment will no longer have an effect and stress corrosion can occur.

Conclusion: The use of 304L is expected to be acceptable for the shell. The tubes should be a higher alloy, such as G-30.

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e Crevice Corrosion
See Pitting.

Conclusion: See Pitting

f Corrosion at Welds
Weld corrosion other than pitting or crevice corrosion is not considered a problem in the proposed environment

Conclusion: Weld corrosion is not considered a problem.

g Microbiologically Induced Corrosion (MIC)
MIC is normally observed at lower pH conditions and temperatures. Although microbes can live at very low pH, and probably high pH, as well as at 572°F and in radiation fields, no reports of MIC in the proposed conditions have been reported.

Conclusion MIC is not considered a problem.

h Fatigue/Corrosion Fatigue
Corrosion fatigue is not a problem particularly in a properly designed unit.

Conclusion: Not considered a problem

i Vapor Phase Corrosion
The vapor phase portion of the tank will be continually washed with condensing vapors and periodically sprayed with wash water via the vessel wash rings while also being spattered with caustic.

Conclusion: Based on Zapp's work (1998), no vapor phase corrosion is anticipated.

j Erosion
Velocities within the evaporator are expected to be low.

Conclusion: Not a concern

k Galling of Moving Surfaces
Not applicable

Conclusion: Not applicable.

l Fretting/Wear
Not anticipated to be a problem.

Conclusion: Not expected to be a concern.

m Galvanic Corrosion
For the environment and the proposed alloys, there is not believed to be a concern.

Conclusion: Not a concern

n Cavitation
Not applicable.

Conclusion: Not applicable.

o Creep
Even though the system is designed for temperatures up to 311 °F, the temperatures are sufficiently low for the given pressures to not be a concern.

Conclusion: Not applicable.

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PLANT ITEM MATERIAL SELECTION DATA SHEET
OPERATING CONDITIONS

Materials Selection Data

Material Selection Data Sheets for The Pretreatment Facility

Component (Name/ID) FEP-RBLR-00001 A/B
System FEP

Operations

Chemicals	Unit	Cold Startup	Normal Operation*	Standby/Idle	Cleaning	Accident
Aluminum	g/l	N/A	3.0E+01	N/A	N/A	N/A
Chloride	g/l		5.6E+00			
Fluoride	g/l		7.9E+00			
Hydroxide	g/l		2.6E+00			
Iron	g/l		6.4E+00			
Nitrate	g/l		7.8E+01			
Nitrite	g/l		2.3E+02			
Phosphate	g/l		1.5E+01			
TOC†	g/l		2.6E+01			
Sulfate	g/l		4.0E+00			
Undissolved solids	g/l		4.0E+01			
Particle size/hardness	μm (##)		N/A			
Other (Hg)	g/l		3.4E-01			
Carbonate	g/l		5.0E+00			
pH	-		1.3E+01			
Dose rate, α, β/γ	Rad		N/A			
Temperature	°F		1.4E+02			
Velocity	fps		N/A			
Vibration			N/A			
Time of exposure	#		1.0E+02			

* Based on Contract Maximum Chemical A/D run at 60/6

\# - % of total; ## - use Mho scale

Assumptions:

Remarks: Stream FEP03

Comments: 2M HNO3 During Cleaning of Separator and Reboiler

[X] Black Cell

[X] Flushing

† List expected organic species: N/A
Use maximum of 2 significant figures

N/A = Information not available or not in Process Engineering Scope